

an encapsulating resin [formed] on the second surface at least partially encapsulating the die.
[and substrate.]

35. (amended) The package of claim 34 further comprising a glob top at least partially encapsulating the wires.

[further comprising a third opening in the substrate for wire bonding the die to the conductors.]

36. (amended) The package of claim [35] 34 wherein the adhesive layer comprises a material selected from the group consisting of filled epoxy, unfilled epoxy, acrylics and polyimide.

[die is bonded face down to the die attach area.]

REMARKS

Amendments to Specification

The title has been amended to more accurately reflect the subject matter of the claims. In addition, the "Cross Reference to Related Applications" has been amended to include a patent number for the issued parent case.

In addition, permission is requested to amend the specification pursuant to 37 CFR §1.117 to secure correspondence between the claims and the specification. In particular original claims 4, 7, 15, 21, 24 and 30 state that the mask (mask 80B-Figure 3C which is recited as the "second mask" in the amended claims) includes an opening (opening 50-Figure 3C) for "*defining* a die attach area" on the substrate (die attach area 50-Figure 3). However, the term "define" or "defining" is not used in the specification. Accordingly, page 11, line 26 of the specification has been amended to state that: "The die attach opening 86 *defines* the die attach area 50 on the substrate 56". The added sentence provides correspondence between the claims and the specification, as required by the rules, and no new matter is present.

Claim Rejections Under 35 USC §103

Claims 24-36 have been rejected under 35 USC 103(a) as being unpatentable over the admitted prior art in view of Lee et al. (U.S. Patent No. 5,796,586).

In response to the 35 USC §103 rejections, the claims have been amended. In addition, the Examiner is asked to consider the arguments to follow.

The amended claims are directed to a semiconductor package 62 (Figure 6B). As shown in Figure 6B, the package 62 includes a substrate 56 comprising a first surface 44 with a pattern of conductors 48, an opposing second surface 46 with a die attach area 50, and a wire bonding opening 64 extending through the substrate 56 from the first surface 44 to the second surface 46. In addition, the package 62 includes a first solder mask 80A having openings 82 for attaching solder balls 88 to the conductors 48, and an opening 84 (Figure 3C) for wire bonding to the conductors 48. The package 62 also includes a second solder mask 80B having an opening 86 (Figure 3D) on the die attach area 50.

As also shown in Figure 6B, the package 62 includes a semiconductor die 16 placed face down (circuit side down) through the opening 86 in the second solder mask 80B, and attached directly to the substrate 56 in the die attach area 50. An adhesive layer 72 (Figure 6A) attaches the face of the die 16 directly to the substrate 56. The package 62 also includes wires 94 placed through the wire bonding opening 64 in the substrate 56, and bonded to bonding pads on the face of the die 16, and to bonding pads 52 (Figure 6A) on the conductors 48. In addition, solder balls 88 are placed through the openings 82 in the first solder mask 80A, and attached to ball bonding pads 54 (Figure 6A) on the conductors 48. As also shown in Figure 6B, an encapsulating resin 90 is molded over the die 16, and over the second solder mask 80B. Further, a glob top 92 can be placed over the wires 94, and in the wire bonding opening 64 to protect the wire bonds.

Amended Claims

Each independent claim has been amended to include recitations which emphasize features of the presently claimed package that are not suggested by the prior art. With the amended recitations, the claims "taken as a whole" are submitted to be unobvious over the prior art.

Amended independent claim 24 states that the die has a "first outline" and that the "opening in the second mask" (e.g., opening 86-Figure 3C) has a "second outline substantially matching the first outline to define a die attach area on the second surface". Antecedent basis for the additional recitations is contained on page 11, lines 23-25, of the specification, and in the originally filed claims. Amended independent claim 24 also recites "an adhesive layer between the die and the substrate in the open die attach area bonding the die directly to the second surface."

Lee et al. was cited as illustrating a solder mask 218 (Figure 3) on a surface 116 of a substrate 216 (Figure 6) that is open in a die attach area 204 (Figure 3). However, as shown in Figure 6, Lee et al. also teaches opening the solder mask 218 over the entire center portion of the surface 116 on which an encapsulating material 224 is formed (column 6, lines 56-60 of Lee et al.). The purpose of the open center portion is so that the encapsulating material 224 will have better adherence to the substrate (column 6, lines 56-60 of Lee et al.). In addition, Lee et al. teaches forming the solder mask 218 out of an anti-adhesive material such that excess encapsulating material 224 can be removed without damaging the solder mask (column 5, lines 55-62 of Lee et al.).

Lee et al. does not specifically teach leaving the die attach area 50 (Figure 3C) uncovered such the "adhesive layer" bonds "the die directly to the second surface", as presently claimed. Lee et al. also does not specifically

teach that die adhesion is improved by direct attachment of the die 16 (Figure 3D) to the substrate 56 (Figure 3D).

Further, Lee et al. does not suggest "defining" the die attach area by the outline of the open area of the substrate. In the embodiment shown in Figure 3 of Lee et al., the open portion of the substrate is substantially larger than the die 220, such that the encapsulating resin 224 (Figure 6) attaches directly to the substrate 216, rather than to the solder mask 218. In the embodiment shown in Figure 7 of Lee et al., a polyimide solder mask 218' must also be substantially larger than the die 220, to expose portions of the conductors 202 for wire bonding.

The Akram et al. ('585) patent, which was not specifically cited in the rejections, is stated in the Office Action to include "an opening in the second mask defining the die attach area on the substrate (Fig. 4D, 4E and Fig. 1-10; Col 7)". However, the completed package 10 in Figure 1 of Akram et al. does not include a mask with an opening defining a die attach area. The masks 42 (Figure 4A) and 42A (Figure 4D) are etch masks (col. 6, line 67 and col. 7, lines 34-36) which are stripped following the etch procedures (column 7, lines 21-25, column 7, lines 43-46).

In view of these differences, and the additional recitations, amended independent claim 24 is submitted to be unobvious over the combination of the admitted prior art and Lee et al.

Dependent claim 25 has been amended to recite an "encapsulating material encapsulating the die and the second mask." On the other hand, Lee et al. teaches forming the encapsulating resin 224 (Figure 6) on the open center portion of the surface 116 (Figure 6) rather than on the solder mask 218 (Figure 6). Lee et al. in effect teaches away from encapsulating the solder mask 218, as the primary teaching is forming the encapsulating material 224 on the open center portion of the surface 116.

Dependent claim 26 has been amended to recite that "the substrate includes a wire bonding opening and the die is aligned with the wire bonding opening, bonded circuit side down to the second surface, and wire bonded to the conductors." The present claimed package construction is referred to as board-on-chip (BOC). In Lee et al. the die 220 (Figure 6) is back bonded to the surface 116 (Figure 6), and the interconnect circuitry (conductors 202) is located on the same side of the substrate as the die (i.e., on surface 116). The Lee et al. package is referred to as chip-on-board (COB). The present BOC package provides a thinner package, and simplifies the substrate 56, as interlevel conductors in the substrate are not required.

Admittedly, the BOC package construction is known in the art, as exemplified by Figure 1A of the present application. However, Applicant's would argue that one skilled in the art at the time of the invention would have no incentive to combine Lee et al. with the prior art to achieve the presently claimed method, as Lee et al. does not specifically teach improved adhesion of the die to the substrate using an open die attach area on a solder mask. In addition, there is no teaching in the prior art that would provide the incentive for the proposed combination of Lee et al. and the prior art, as the prior art specifically teaches bonding the face (circuit side) of the die directly to the solder mask.

Furthermore, the improved adhesion provided by the claimed method significantly increases the reliability of a BOC package, as there is less surface area on the face of the die available for bonding than with a back bonded die. In addition, the face of the die is coated with a passivation layer which typically comprises a glass material (e.g., BPSG) that is less adhesive than the uncoated backside of the die.

Independent claim 27 recites a "circuit side down" mounting of the die in an open die attach area having a "bonding opening" (e.g., opening 64-Figure 6A). Claim 27 also recites "wires in the bonding opening wire bonded to the

die and to the conductors" (e.g., wire bonded wires 94-Figure 6A). As previously argued, improved adhesion is a significant improvement for a BOC package. Accordingly, the improved package reliability provided by the present method is submitted to be an indicia of the unobviousness of the method.

Independent claim 30 is similar to independent claim 24 in that it states that the die has a "first outline", and that the "second mask" (e.g., mask 80B-Figure 3C) has an "opening" (e.g., opening 86-Figure 3C) with a "second outline substantially matching the first outline to define a die attach area on the substrate". As previously argued, the claimed method is submitted to be unobvious over the art, as the reliability of the resultant package is significantly improved.


Independent claim 34 recites a "circuit side down" mounting of the die, and recites "an encapsulating material on the first surface that substantially covers the die and the second mask". As previously argued, Lee et al. teaches leaving the mask 218 (Figure 6) substantially uncovered by the encapsulating material 224 (Figure 6). Lee et al. also specifically teaches an "anti-adhesive" material for the solder mask (218-Figure 6 or 218'-Figure 7). On the other hand, the presently claimed method can be practiced with any type of solder mask material (adhesive or anti-adhesive), as the main feature is improved adhesion of the die to the substrate.

Conclusion

In view of the above arguments and amendments, favorable consideration and allowance of claims 24-36 is respectfully requested. Also being submitted with this Amendment is an Information Disclosure Statement. Should any issues arise that will advance this case to allowance, the Examiner is asked to contact the undersigned by telephone.

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July 26, 2000
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